Universal Terminology

CHAPTER 2: BASIC OBJECTS

This chapter considers the basic objects making the $\mathbf{T}_{logy}$and presents textual and formal definitions. The terminology is the language part of an ontology that is supposed to be independent of the representation of its content. It will be shown that the terminology must preferably be language independent to insure its universality regarding different languages.
A definition of what is a $\mathbf{T}_{logy}$is presented on a formal basis. Multiple authors develop lists of terms and other classifications, often without formal background. Indeed, the scientific community is in need of a more formal approach of this domain. This is a necessary condition in order to make possible the interchange of information between computer applications.
This document is the chapter 2 of the book Universal Terminology which presents a global documentation on the $\mathbf{T}_{logy}$.

Contents

2.1 Introduction . . . 3
2.2 Basic definitions . . . 3
2.2.1 Class, instance, entity and unit. . . . 3
2.2.2 ISA link, taxonomy . . . 6
2.2.3 Specific and generic entities . . . 7
2.2.4 Part_of link, Partonomy . . . 7
2.2.5 Terminology . . . 9
2.2.6 Vocabulary . . . 11
2.2.7 Term . . . 11
2.2.8 List . . . 12
2.3 Formal part_of . . . 13
2.4 Properties . . . 14
2.4.1 Symmetric property . . . 14
2.4.2 Mid-line property . . . 14
2.5 Entity type . . . 15
2.5.1 Single entity . . . 15
2.5.2 Composite entity . . . 16
2.5.3 Paired entity . . . 17
2.5.4 Paired composite entity . . . 17
2.5.5 Lexical entity . . . 17
2.5.6 Vocabulary entity . . . 17
2.5.7 Interface entity . . . 18
2.5.8 Reference entity . . . 18

2.6 Unit type 19
2.6.1 Single unit 19
2.6.2 Pair unit 19
2.6.3 Pset unit 19
2.6.4 Set unit 19
2.6.5 Mset unit 19
2.7 Log of updates 20
2.8 Credentials 20

2.1 Introduction

This document aims at defining the basic objects being the components of the $\mathbf{T}_{logy}$, the types of entities entering in the TAH hierarchy, their basic properties and the links governing the hierarchical trees.

In a first part, the most basic definitions are developed: what is a terminology, what are the entities? This exercise is difficult and does not pretend to bring any final solution. However, it introduces the inherent formalism of ontology, which is a science in itself. The interested readers may find additional and deeper information elsewhere (see the bibliography).

The second part is about properties of interest in the domain of anatomy. Here also definitions of the important properties are proposed. Formal definitions have been developed in order to facilitate the communication between computer applications.

The third part is about entity types of physical entities, based on 3 basic properties: materiality, composition and symmetry. The entity types strictly regulate the TAH partonomic hierarchy, because the hierarchical links are dependent on the type of father and child entities.

The fourth part is about the unit types used in the $\mathbf{T}_{logy}$.

The partonomic links are all specializations of the *part_of* relation. This complex relation is considered in details. In particular it is dependent on the types of the father and child entities: each possible co-occurrence must be considered in turn. For example LA:*ossa carpales* *PairSubsetOf* LA:*ossa manus* is a relation between two paired set entities. The relation PairSubsetOf *isa* PartOf is verified and participates to the specialization of the *part_of* relation. The partonomic links are considered in details in chapter 14.

2.2 Basic definitions

In this section, all formal definitions of importance in TAH are explicitly settled and briefly discussed.

2.2.1 Class, instance, entity and unit.

A first definition cannot be based on other definitions because it is the first. Then it necessarily is a sort of axiom or an initial affirmation by the authors of the terminology:

Entity
`An entity (definition) is a universal ontological term of art embracing objects, processes, functions, structure, time and places, depending on the underlying domain of concern. An entity is referencing an object of the domain and denotes the collection of all occurrences of the object.`

This definition will be re visited below under the name anatomical entity.

An entity is an abstract object for the representation of the domain of concern. There are two kinds of entities. First are the entities referencing an object existing in reality. They will be defined below as **specific entities**. Second are the entities linked to a representation artifacts which are necessary for the

proper description of these objects. They will be defined below as **generic entities**.

This dichotomy of objects call for the definition of physical and non-physical entities.

Physical entity
`A physical entity (definition) is an entity which has a dimension and exists in reality.`

Most entities in the TAH partonomy are physical entities. They are split into material and immaterial entities. Only the physical entities enter in the composition of the TAH maximal partonomy.

The physical property is true for any dimensional entity from 0 to 3 dimensions. A 0 dimension entity is a boundary entity for a 1 dimension entity: it is an anatomical point.

In the domain of human anatomy, the physical entities are predominantly related to parts of the human body, being material objects or boundary limits: LA:*manus* is a material object and LA:*sulcus nasolabialis* is a boundary limit.

Material entity
`A material entity (definition) is a single unpaired physical entity having a mass.`

It is made of some matter, solid, liquid or gaseous. This is the most common entity in $\mathbf{T}_{logy}$. Material entity may be either relatively specific, like sternum,or relatively general like columna vertebralis or even systema urinaria. In all situations we are in presence of singular preferred terms with no composition, nor parity. The usage of general singular term is particularly useful in order to correctly specify the part-whole TA hierarchy.

Immaterial entity
`An immaterial entity (definition) is a single unpaired physical entity without mass and with 0 to 3 dimensions.`

It is without matter and can be present as a space, a surface, a line or a point. Consequently it has respectively 3, 2, 1 or 0 dimensions. In the TA, description of the human body by gross anatomy, some 10 % of entities are of this type.

For example, an immaterial entity may have a volume like cavitas laryngis or it may be a two-dimensional surface like facies costalis scapulae, which evidently is not planar. A zero dimension entity is a point, like bregma.

The existence of general singular terms is also verified with immaterial entities.

Non-physical entity
`A non-physical entity (definition) is an entity without dimension which represents an abstract concept used for the representation of the terminology`

Non-physical entities were not frequent in TA98: they were related to the expression of pattern and relationships and only play a side role. In the TAH, the non-physical entities are exclusively defined in the taxonomy.

An example is distalis. Another example is abductio. All the part_of links are also to be considered as non-physical entities. The complete description of the domain necessitates multiple non-physical entities. The non-physical entities are the words of the vocabulary, the relations connecting the entities, the type of entities and other representation objects.

Class
`A class (or universal, type, kind) (definition) is a representation of all possible occurrences of an object, distributed in space and time.`

Classes share a common essence. Each class definition specifies the essence shared by the corresponding instances via the specification of (i) a **genus**, which is some wider class to which the given class belongs, together with (ii) a **differentia** which mark out its instances within the wider class, according to the Aristotle principle of genus and differentia.

A class belongs to the domain of representation and not to the reality. A class is an abstract concept for representation of the reality.

Anatomical entity
`An anatomical entity (definition) is a` **`class`** `in the domain of gross anatomy, possibly extended to sub-domains of anatomy.`

The $\mathbf{T}_{logy}$is essentially concerned by the domain of gross anatomy, but not limited to. Indeed extensions are possible - and does occur - in multiple sub-domains of anatomy, like histology, molecular biology, embryology, etc, as well as the general domains like physics and chemistry. Such extensions are uniquely based on pragmatic criteria.

Instance
`An instance (definition) is a specific occurrence in reality of an object of a class.`

An instance is an individual (a particular, a token) of a specified class, located in space and time. Classes exist in their respective instances.

No two instances of the same class are identical in the domain of gross anatomy. They are different in size, form, matter, etc, but they all share a set of common properties.

Instances are largely distributed in space and time. The class LA:*sternum* not only includes as instances the more than 9'000'000'000 sternums actually available on Earth, but also the past and future sternums on a range of time where the human species is considered as stable.

In the TAH documentation, an entity class or an entity instance is often call an entity, and the difference has to be inferred from the context.

Within a taxonomy, one can distinguish two different types of classes according to their position in the tree, giving different types of instances. The true instances correspond to the classes which are directly instantiated in reality.

True instance
`A true instance (definition) is exclusively an instance of the entity itself, but not an instance of one of its descendants.`

Indirect instance
`An indirect instance (definition) is an instance of a class which subsumes into one or multiple leaf nodes in the taxonomy.`

The indirect instances correspond to classes from which the leaves of the taxonomic tree inherit, but which themselves are partial differentiae in the definition of the leaf entities. An indirect instance does not exist in reality. For example, there is no scapula in reality, no drawing of it, no X-ray. There is only a left scapula or a right scapula. Therefore, a left scapula is an indirect instance of scapula as well as an indirect instance of flat bone.

Unit
`A unit (definition) is an assembly of entities counting one to five items related to a` **`generic entity`**`.`

The typical example of a unit is a pair unit like LA: *clavicula*. It is the assembly of the specific entity *clavicula* and the three specific entities *clavicula (pair)*, *clavicula sinistra* and *clavicula dextra*.

Only the units get a term as their name in the $\mathbf{T}_{logy}$. The entities constituting a unit have their respective terms automatically generated from the unit term. This feature is valid for all languages of the $\mathbf{T}_{logy}$.

2.2.2 ISA link, taxonomy

ISA link
`An ISA link (definition) is the relation between two classes which preserves all specifications and properties.`

The ISA link is the unique relation used when building the taxonomy. In TAH, no ISA link may be present outside of the taxonomy.

Taxonomy
`A taxonomy (definition) is a mathematical tree with a root (a class or unique maximal genus) connected to all other classes via finite chains of ISA relations satisfying the principle of single inheritance.`

The Foundational Model of Anatomy (FMA) contains a taxonomy, which constitutes an inherent part of the revised TAH. However, this taxonomy had to be modified or updated in order to cope with new features present in this revision.

The principle of single inheritance has been adopted, following the FMA. It means that any entity has one and only one father in the taxonomy, without exception (except the top entity that has no father). Other authors have developed taxonomies with the principle of multiple inheritance, but that's a different approach of the reality, not considered here.

TAH reference taxonomy
`The TAH reference taxonomy (definition) is a revised subset of the FMA taxonomy, either augmented or limited to the entities present in TAH.`

This TAH taxonomy was originally copied from the FMA taxonomy. However, some divergences have been found and corrected.

The issued TAH taxonomy is published in Latin, in conformity of the rules prevailing for the entire TAH. In addition, according to the multilingual capabilities of our $\mathbf{T}_{logy}$, it can be visualized in any interface language.

2.2.3 Specific and generic entities

Entities play different roles depending on their belonging to the partonomy or to their position in the taxonomy.

Specific entity
`A specific entity (definition) is an entity which is directly referring to a physical entity.`

About half of all entities are leaves in the taxonomy. The specific entities constitute altogether a global partonomy under the top entity LA:*corpus humanum*. The specific entities are to be found in the dissection room. Any entity which can be physically found in a human body, isolated and put "on the table" is a specific entity.

It should be noted that this definition of a specific entity as a leaf of the taxonomy is only valid in a complete taxonomy of the domain. For example LA:*humerus* is not a specific entity, because a complete taxonomy would necessarily add LA:*humerus sinister* as a child of the former entity, making it a non leaf entity.

Following the above example, there is another specific entity to mention, the LA:*humerus (par)*, that is in fact the partonomic father of LA:*humerus sinister* and LA:*humerus dexter*. The pair of humerus is the composite entity made of the two humeri found in a human body.

The partonomy (to be defined thereafter) is exclusively made of specific entities.

generic entity
`A generic entity (definition) is an entity of the taxonomy which cannot have true instances.`

The taxonomy is exclusively made of generic entities, except the leaves that are always specific entities.

2.2.4 Part_of link, Partonomy

In this book we use the word partonomy as a synonym of meronomy, that is preferred by some authors. Wikipedia recognizes both words.

The domain of anatomy is particularly concerned by part-whole relationships. This is due to the fact that a natural presentation of the anatomy of the human body is realized under the form of the anatomic atlas. The anatomic atlas presents any topic (the whole) together with all the relevant constituting entities (the parts) under the form of drawings. This paradigm is natural and universally widespread: it is a fundamental approach when teaching anatomy to students.

When relating an entity to any of its constituting parts, one is facing a relation named part_of. This is well-known relation frequently encountered in different domains and largely documented. However, on the contrary of the ISA relation prevailing in the taxonomy, this relation is somewhat more complicated and difficult to formalize. In addition, it receives different meanings in different context, in such a way that the safe exchange of information containing this relation is doubtful. And how many authors have claimed that the blood is part_of the artery: a true error!

part_of relation
A part_of relation (definition) is a relation between an entity and one of its constituting part, valid for physical entities. It states that any matter or space of the part is also matter or space of the whole and that there is some matter or space of the whole that is not matter or space of the part.

The part_of relations applies to material entities as well as to immaterial entities. In this later situation a space can be the child of a larger cavity; or a face can be a child of a volume.

This textual definition is useful for communication between human readers, but anyway it is not precise enough. In the next section, this definition will be reformulated using a mathematical language.

Partonomy
A partonomy (definition) is a partial order of entities related by part_of relationships.

Global partonomy
The global partonomy (definition) is a partonomic hierarchy under a top entity, including all specific entities via chains of part_of links.

The global partonomy includes all specific entities but the generic entities, and which top entity is named corpus humanum masculinum or corpus humanum femininum. The global partonomy necessarily contains all specific entities of the taxonomy. All their instances are true instances.

Generic partonomy
A generic partonomy (definition) is a partonomic hierarchy under a generic entity, which acts as a model for its descendants in the taxonomy.

The number of generic partonomies is not limited. Generic partonomies are defined around generic entities, for example vertebra or costa. By definition, the partonomic links are inherited through the taxonomy. But the importance of generic partonomies is increased when considering microscopic entities below the level of tissues.

2.2.5 Terminology

Terminology
`A terminology (definition) is a representation artifact providing language independent terms to the collection of relevant entities in a domain, with focus on identification, definition and naming.`

This definition declares a direct connection between a term (to be defined below) and an entity of the domain. In addition it makes explicit the three facets of the terminology: the identifiers (see chapter 3), the definitions (see chapter 14) and the language aspects (see chapters 8 and 9).

This definition can be compared with the one presented in [Smith et al., 2006]. It is said there: *A TERMINOLOGY is a representational artifact consisting of representational units which are the general terms of some natural language used to refer to entities in some specific domain.* The idea of a representation artifacts was introduced by this article. However, the author was not aware at this time of the necessity of the language independence, or at least did not mention it.

[**Smith et al., 2006**]
This paper is a basic introduction to the ontology of the anatomical domain. It insist on the separation of the reality on one side and the representation of that reality on the other side. It defines several basic objects like universals and instances, continuants and occurrents as well as more complex objects like ontology or terminology.

Indeed, the strong statement in this definition is the assertion "language independent". Let ignore it in the first steps of discussion about this definition.

TAH is a terminology for the domain of gross anatomy, including new developments in histology. In its source version of 1998, it contains some 7500 independant entities, which corresponds to the level of knowledge of general medicine, but generally not sufficient for specialties. TAH has been originally published in 1998, under the form of a sequential listing in a book form. The TAH objects were identified by a 11-characters code, which defines an order of presentation, but this code will progressively disappear. Official naming is in Latin and English equivalent are provided. Important synonyms are provided as well as links to eponyms. TAH is intended to be translated in several languages.

Paradoxically, a terminology cannot achieve its goal of naming entities if these entities are not precisely delineated or identified, because in theory a scientific name applies uniquely to a formally well defined entity. Terminologia Anatomiae Humanae meets this problem. Indeed, TAH assumes the existence of a universal anatomical knowledge shared between human beings, which at a first glance acts as universal definition of anatomical entities. But this definitional corpus is hard to make explicit. The paradox lies in the fact that on one side TAH is based on existing definitions and on the other side it contributes to promote and extend these definitions. Together with the FMA, TAH formally specifies relations and properties of anatomical entities in a systematic and scientific approach.

The TA98 11-characters code suggested a partonomy of the domain of gross anatomy. But the lack of a formal basis in the 1998 source version makes hard the task of alignment with other biomedical ontologies and computer interchange applications. This was considered as a major impediment for a large acceptance of this initial version of the anatomical terminology. It is a goal of the revised TAH to resolve this challenge.

A more detailed discussion of what is a term will be undertaken in the chapters 8 and 9, respectively entitled Anatomy of a term and Grammar of terms.

Let now consider the problem of dependency to one or more languages. A terminology is a representation of the reality, in our situation a representation of the human body. Is a human body more Latin or more Mongolian than it is English or French? Is the reality more important in one language than another? Evidently not, because anatomy itself is universal. But the terminologies have always preferred some languages to others. The reason is simple, the authors of the terminologies did not had the knowledge and/or the tools and/or the manpower for the management of multilingual terminologies, or better for the development of a universal terminology.

In this situation, because this essential problem was clear to some authors of terminologies, the Latin was advanced as a relatively neutral language, not dependent on any country and other political considerations. In this way Latin was proposed as a universal language. This is the basis of Terminologia Anatomica. The inconvenient with Latin is the reality that it is not sufficiently taught in several countries and that a number of anatomists do not feel comfortable with Latin. This is a fact, not an opinion! A recent referendum among the National Societies of IFAA has shown a majority not really favorable to Latin.

Facing this dilemma when building the TNA terminology, it became rapidly clear that the development of an abstract, language independent representation was feasible. There are main reasons supporting this statement:

- Neccessity: there is a strong need for a solution.
- Feasibility: the computer tools to support an abstract representation are there.
- Cost or time: the domain of anatomy, to a linguistic point of view, is of a reasonable size.

On this basis, the TNA was implemented under the concept of a Universal Terminology, meaning it is independent of any language. And in order to give a proof of concept, the TNA was immediately made available in 5 languages: Latin, English, French, Spanish and Russian. Other languages are underway. The translation was automatized and the validation by native speakers was performed in relatively short delays. The final quality is at least as good as it is for manually prepared lists of terms.

The adaptation of this Universal Terminology to the whole TA is only a matter of manpower.

The present book is a scientific documentation of what is the Universal Terminology. The programs necessary to support this terminology have been made available in the public domain under GitHub.

2.2.6 Vocabulary

In the common situation, the vocabulary is a collection of words in a specific language. But, due to the fact that we are building a terminology independent of any language, we need to define the vocabulary at an abstract level. Then, we can map this abstract level to the vocabulary in any vernacular.

Lexeme
`A lexeme (definition) is an abstract vocabulary representation of a word to be used for the naming of the objects of the terminology. The types of lexemes are the noun, the adjective, the prefix or the invariant.`

The abstract vocabulary of the $\mathbf{T}_{logy}$is made of lexemes, which can be currently of 4 different types for each vocabulary entry: the noun, the adjective, the prefix and the invariant. Each vocabulary entry may contain from one to four lexemes for each specific language.

The vocabulary itself is a collection of entries, each being related to an abstract unit of language corresponding to the words of the different languages, where the terminology will be expressed. These entries are predominantly specific to the domain of anatomy, though common words are necessary in addition.

Vocabulary
`A vocabulary (definition) is a collection of lexemes necessary for the textual expression of the terminology. The lexemes can be mapped to any language specific words.`

In practice, the $\mathbf{T}_{logy}$defines the lexemes as a language independent process, without worrying about the target vernaculars ans their representation problems, like syntax, synonyms, homonyms, traditional preferences, etc. In a later distinct process, totally independent for time schedule and manpower, to be undertaken for each candidate target language, the universal representation is mapped to a specific language. There is no imposed connection between one language and another language. This strategy guarantee the independence of the $\mathbf{T}_{logy}$from any language.

However, one language is mapped initially by the authors of the terminology: Latin. This guarantees two major aspects: 1) a suitable mapping example is provided at the level of each term of the terminology and demonstrate the feasibility of our universal model; 2) this maintains the traditional role of Latin for anatomical terminologies and insures a good transition from the past terminologies. But this Latin mapping is in no way necessary when performing a mapping to another language.

2.2.7 Term

Term
`A term (definition) is a ordered sequence of lexemes controlled by a universal grammar, which can be automatically transposed in an equivalent term of any language, where a language grammar has been created.`

This definition is about a universal term and establishes the the principle of automatic translation in any vernacular. To do that, regarding a specific language, one has to rule out the transposition links between the universal grammar and the language grammar. In general, the transposition rules have to solve different problems:

- Sequence of lexemes: the order of the lexemes in the language term is in general different from the order specified by the universal order. For example, adjectives follow the noun in the universal grammar as well as the French and Spanish grammar, but precede the noun in English and Russian.
- Genitive: the formation of genitive is different in languages with declension than in other languages. For example Latin and Russian have a declension, but English, French and Spanish make the genitive with a preposition.
- Variability of adjectives: the adjectives may be variable in gender, number and/or case depending on the target language.
- Language exceptions: here and there, some language need atypical rules. For example, traditional Latin may position a genitive group within the nominative group which it is depending on.
- Prepositions: the usage of preposition may govern different cases in different languages.

The full discussion of the automatic translation process is given in chapter 10.

2.2.8 List

The lists play an important role in the terminology and are not only a presentation artifact. A list is precisely defined by three parameters:

- the content: a list is made of a top entity, acting as an identifier of the list, followed by a hierarchical expansion, with an indentation process generated from the hierarchy.
- the time: any list is precisely valid at the point in time of its creation and can be potentially different of any preceding or succeeding version.
- the language: a list resulting from a mapping process from the universal representation of the terminology to a target language, not synchronized to another language, is dependent of the quality of the actual implementation of the target language.

List
`A list (definition) is a ordered sequential collection of entities - usually represented by their terms - that is dependent on a hierarchy of the terminology, valid at a specified point in time, and expressed in a specific language.`

The lists are particularly sensible to the updating process of the terminology, especially long lists with more than hundred items. Updates are necessary for at least three reasons: the correction of errors; the permanent validation of the content by experts; the improvements in the domain of medicine. It is certainly uncomfortable to a casual user of the terminology to find a specific list of his interest with a different size at different dates of access. In order to minimize this problem, the concept of published lists has been created: they are frozen lists at specific points in time.

Another process concerns the lists: a signature of a list can be computed, dependent on the identifiers of items, the hierarchical indentation and the overall size of the list. But the signature is entirely independent of the used language of the list. When the list first created, the signature is computed and stored in the database. At a later time, when the list is regenerated possibly in another language, the signature is recomputed and compared to the original value. A match of the signature guarantees the integrity of the list.

2.3 Formal part_of

In order to cope with the complexity of the part_of relation, it is necessary to develop a formal approach. The above definition is perfectly valid, but it is under the form of a text. Therefore, it can be hardly communicated to a computer. A more formal context is necessary, which will also be helpful for further definitions of properties or relations.

To do that, we follow a line similar to the infinitesimal calculus. We consider that any material entity is made of fine grains of matter which are adjacent and continuous, whatever is the form or shape of the considered entity. The size of the grains is sufficiently small compared to the whole entity to be sure that it does not interfere with the properties of the entity. In this approach, any entity A can be defined as the sum of its constituting grains δA giving:

$$A = \sum \delta A$$

It is clear that the grains of our formula have nothing to do with human tissues or cells: they are a pure mathematical model outside of the real world.

We can now reconsider our original definition and reformulate it in the mathematical language:

A part_of B if

given $A = \sum \delta A$ and $B = \sum \delta B$

1) $\forall \delta A \exists \delta B : \delta A = \delta B$

2) $\exists \delta B : (\forall \delta A \text{ then } \delta B \neq \delta A)$

2.4 Properties

A couple of properties are important due to the fact that they enter in the definition of all the variants of the part_of relations. In particular, some of these properties, physical, material, generic, composite and paired, enter in the definition of entity types.

2.4.1 Symmetric property

Symmetric property
`The symmetric property A Sym B (definition) is true when A is symmetric to B relative to the central sagittal plane.`

Let prepare the formal definition of this property. First we define an X horizontal axis and a Y vertical axis in the central sagittal plane. Second we define a Z axis perpendicular to the preceding ones. On this basis, any point in space get coordinates on the three axis. The definition can now be developed:

A Sym B if

$$\text{given } A = \sum \delta A \text{ and } B = \sum \delta B$$

$$\forall \delta A \exists \delta B : \delta A_X = \delta B_X \text{ and } \delta A_Y = \delta B_Y \text{ and } \delta A_Z = -\delta B_Z \text{ and } \delta A_Z > 0$$

2.4.2 Mid-line property

Mid-line property
`The mid-line property Mid ( A ) (definition) is true when A is a mid-line entity relative to the central sagittal plane.`

Mid(A) if

$$\text{given } A = \sum \delta A$$

$$\forall \delta Ai \exists \delta Aj : \delta Ai_X = \delta Aj_X \text{ and } \delta Ai_Y = \delta Aj_Y \text{ and } \delta Ai_Z = -\delta Aj_Z$$

In fact a mid-line entity is like two symmetric entities which are united in the central sagittal plane.

2.5 Entity type

The goal of this section is to analyze what are the entities in the $\mathbf{T}_{logy}$, in other words what type of entities we are speaking of. The original hierarchy of the terminology is a partonomy, a so-called part-whole hierarchy, with the implicit goal of expressing some global entities and all subordinated entries which are part of the first and entering in its anatomical structure. This procedure is derived of the natural way of presenting gross anatomy in atlases from general to particular.

The partonomy is to be contrasted to a taxonomic hierarchy, like the one proposed by the Foundational Model of Anatomy (FMA). Both hierarchies are complementary.

The part-of relation is possibly intuitive to human beings, but a formal definition is not easy to formulate, in order to be in position to control when it is present or not. There are numerous examples in the hierarchy where one does not fit comfortable with this relation in presence of various kind of entities. In other words, a formal extension of the strict part_of relation is necessary to cope with all situations in anatomy.

Entity types governs hierarchical links of the partonomy and reciprocally. Several constraints on links arises from the types of entities at both ends of the relation. For that reason - a thigh control of hierarchical links - it is necessary to formally define the entity types.

The partonomy applies to dimensional entities only or socalled physical entities. In the following discussion, non physical entities are not included, though they exist in the $\mathbf{T}_{logy}$. They are part of the taxonomy, but absent of the partonomy.

Entity types for physical entities are based on three independent properties: materiality, parity and composition. Each of these property is bi-valued: materiality separates entities in material and immaterial entities; composition separates entities in single and composite entities; parity separates entities in paired and unpaired entities. This schema defined 8 entity types and can be nicely represented under the form of a cube (see Figure 2.1).

In addition, 3 alternate types of entities are documented thereafter. They are necessary for a safe universal presentation of the $\mathbf{T}_{logy}$. They are the lexical entities, the vocabulary entities and the interface entities.

2.5.1 Single entity

Single entity
`A single entity (definition) is a physical entity made of a continuous assembly of its constituting matter or spaces.`

$$A = \sum \delta A$$

Examples are: sternum, stomach, atlas.

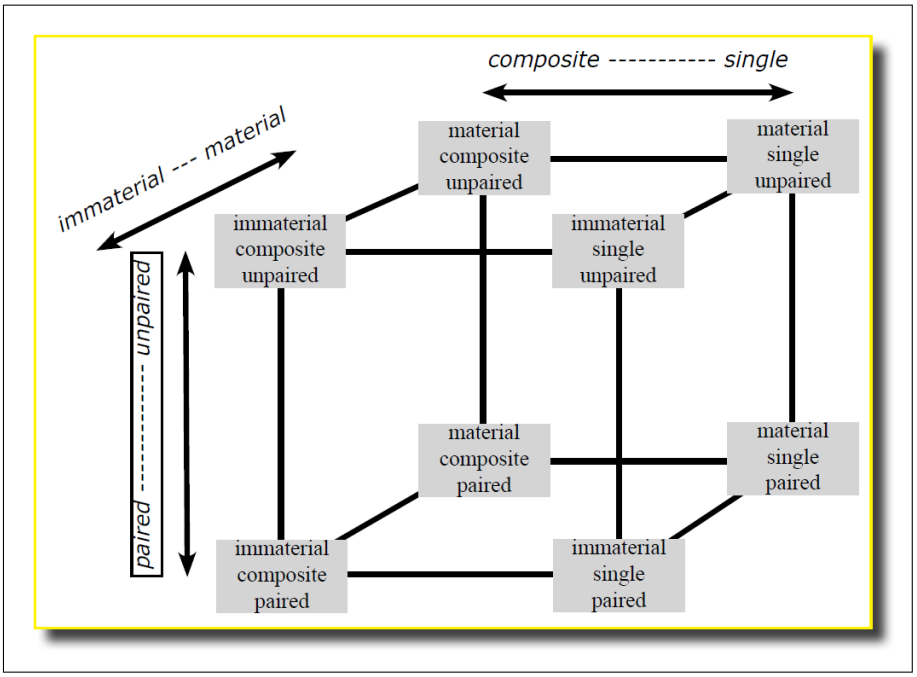

Figure 2.1: The cube of entity types, presenting the 8 types of physical entities.

2.5.2 Composite entity

Composite entity
A composite entity (definition) is an entity made of several distinct components, all corresponding to different occurrences of a generator entity. The generator entity is a generic entity which is the taxonomic father of all the distinct components.

$$A = \sum \delta A_1 + \sum \delta A_2 + ... + \sum \delta A_N$$

The composite entities are the sets which are often found in the terminology, for the expression of objects that occur several time in a human body.

Example: vertebrae cervicales, articulationes interphalangeae pedis.

The above two material and immaterial composite entities are not sufficient for the representation of the reality. Indeed, there are composite entities which are made of a mix of material and immaterial entities. Typically, the entity LA: *morphologia externa telencephali* contains material entities as well as immaterial entities. Such a composite entity is named global composite entity.

Mixed composite entity
A mixed composite entity (definition) is a composite entity with a generator which has simultaneously single and paired children.

By this definition, a mixed set is possibly made of single and paired entities. A typical example is the LA: *cisternae subarachnoideae craniales*: some children cisterns are midline single entities, other are paired entities.

2.5.3 Paired entity

Paired entity
`A paired single entity (definition) is a pair of symmetrical entities through the central sagittal plane.`

$$A = \sum \delta A^L + \sum \delta A^R$$

This type represents all pairs of symmetric entities through the central sagittal plane, which are some 50 % of the TA. Each pair has necessarily two members, which are due to be call left and right members.

By no mean a paired entity could be considered as a composite entity of cardinality 2, because their partonomic descendants are of different nature according to different applicable links. In a pair, each member can be further partitioned in smaller constituents; in a composite entity, any partition of a member of the set is prohibited and the partition is uniquely done by a distribution of the members as subset or individual member.

Example: par radiorum.

2.5.4 Paired composite entity

Paired composite entity
`A paired composite entity (definition) is a pair of composite entities, which are symmetrical through the central sagittal plane.`

$$A = \sum \delta A_1^L + \sum \delta A_1^R + ... + \sum \delta A_N^L + \sum \delta A_N^R$$

An example is par classium costarum, which is a specific entity made of 24 occurrences of the generic entity costa.

2.5.5 Lexical entity

Lexical entity
`A lexical entity (definition) is an entity with a synonym term for another entity.`

During expansion of terms from one entity to another, the main term is used. The expansion on a lexical entity allows the usage of a synonym term.

2.5.6 Vocabulary entity

Vocabulary entity
`A vocabulary entity (definition) is an entity instantiating a lexeme in any specified language, as a noun, an adjective, a prefix and/or an invariant.`

Any universal lexeme used in the composition of a universal term must be made available in any language where a term has to be transposed. Depending on the universal term, different categories of word may have to be proposed.

The corpus of all vocabulary entities defines a vocabulary in each modern language used for presentation of the terminology. This corpus is accessible on the website of the website of the $\mathbf{T}_{logy}$.

2.5.7 Interface entity

Interface entity
`An interface entity (definition) is an entity which provides standard interface texts, legends and bubbles for use in the media where the terminology is displayed.`

As for any entity, the texts are available in all languages proposed for the presentation

2.5.8 Reference entity

Reference entity
`An reference entity (definition) is a pseudo entity under the form of a link to another entity.`

A reference entity is used in the hierarchical lists, when at some precise position in the list the presence of this reference is pertinent, but is not part of the list. A reference means "see also".

2.6 Unit type

2.6.1 Single unit

Single unit
A single unit (definition) is a unit made of only one generic entity.

2.6.2 Pair unit

Pair unit
A pair unit (definition) is a unit made of one generic entity and three specific entities representing a paired object in the domain of anatomy.

2.6.3 Pset unit

Pset unit
A pset unit (definition) is a unit made of two generic entities and three specific entity representing a paired set object in the domain of anatomy.

2.6.4 Set unit

Set unit
A set unit (definition) is a unit made of one generic entity and one specific entity representing a unpaired set object in the domain of anatomy.

2.6.5 Mset unit

Mset unit
A mset unit (definition) is a unit made of one generic entity and one specific entity representing a mixed set object in the domain of anatomy.

Bibliography

[Smith et al., 2006] Smith, B., Kusniercyk, W., Schober, D., and Ceusters, W. (2006). Towards a reference terminology for ontology research and development in the biomedical domain. *In Proceedings of KR-MED 2006*. PDF.

2.7 Log of updates

18 May 2024 Full revision of the chapter with introduction of formal definitions.

26 Dec 2023 Extension of definitions for the units.

30 Mar 2022 Standardisation of the file as a chapter.

10 Mar 2021 Creation of the file.

2.8 Credentials

This document is part of the book "Universal Terminology" accompanying the website on Terminologia Anatomica, sponsored by the University of Fribourg, Switzerland. It expresses the vision of the authors of the $\mathbf{T}_{logy}$about the foundations of the science of ontology, supporting the here presented terminology. Despite it is as exact as possible, close to the reality of the database of the terminology and the surrounding software, approximations, errors and ambiguities are possible and should be considered as independent of their willingness and intents.

Identified comments about the content of this document and the website and its presentation are welcome. An appropriate answer will be given when pertinent.

Authentic URL of this file: https://ifaa.unifr.ch/Public/TNAEntryPage/help/Chap02.pdf. It gives access to the last update of the present document.